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National Eutrophication Survey, Las Vegas, Nev

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

Mar 77

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NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES

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and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT

ON

ALTUS RESERVOIR

GREER AND KIOWA COUNTIES

OKLAHOMA

EPA REGION VI

WORKING PAPER No. 581

WITH THE COOPERATION OF THE

OKLAHOMA DEPARTMENT OF POLLUTION CONTROL

AND THE

OKLAHOMA NATIONAL GUARD

MARCH, 1977

REPORT ON ALTUS RESERVOIR

GREER AND KIOWA COUNTIES, OKLAHOMA

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Eutrophication Survey Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 581

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

March 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Oklahoma Department of Pollution Control for professional involvement, to the Oklahoma National Guard for conducting the tributary sampling phase of the Survey, and to those Oklahoma wastewater treatment plant operators who provided effluent samples and flow data.

Dr. Denver Talley, Director, Oklahoma Department of Pollution Control; the staff of the Oklahoma Water Resources Board; and the staff of the Oklahoma State Department of Health reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

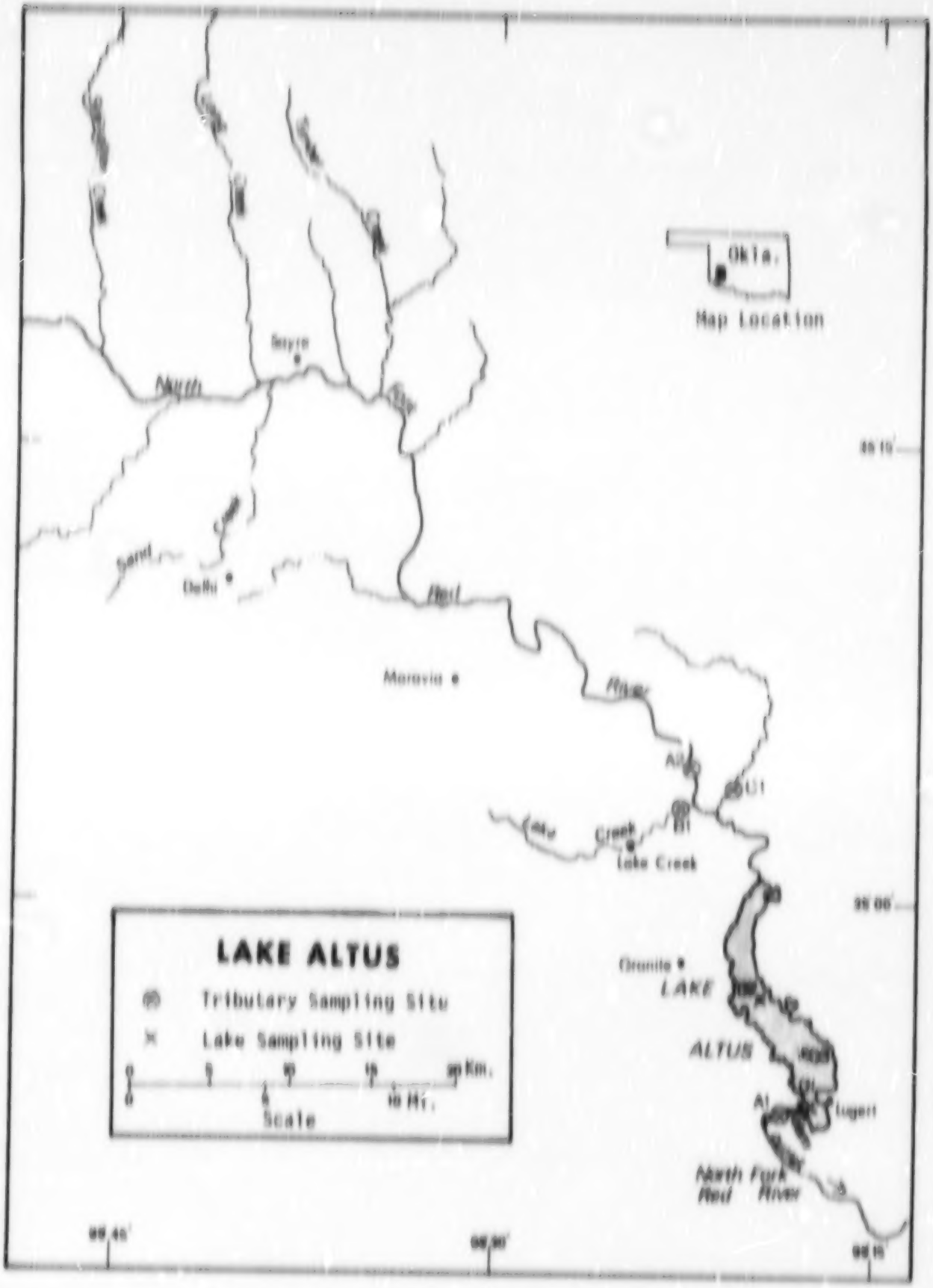
Major General John Coffey, Jr., the Adjutant General of Oklahoma, and Project Officers Colonel Curtis W. Milligan and Major James O. Maney, Jr., who directed the volunteer efforts of the Oklahoma National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OKLAHOMA

LAKE NAME	COUNTY
Altus Reservoir	Greer, Kiowa
Arbuckle Lake	Murray
Lake Elsworth	Caddo, Comanche
Lake Eufaula	Haskell, McIntosh, Okmulgee, Pittsburg
Fort Cobb Reservoir	Caddo
Fort Supply Reservoir	Woodward
Foss Dam Reservoir	Custer
Lake Frances	Adair
Grand Lake O' The Cherokees	Mayes, Delaware, Craig, Ottowa
Lake Hefner	Oklahoma
Keystone Reservoir	Tulsa, Creek, Osage, Pawnee
Oologah Lake	Nowata, Rogers
Tenkiller Ferry Reservoir	Cherokee, Sequoyah
Lake Thunderbird	Cleveland
Wister Reservoir	LeFlore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Map Location
Boyce
North
Fork
Red
River
Dalhi
Red
River
Moravia
Lake Creek
Granite
LAKE
ALTUS
Lugert
North Fork
Red River
LAKE ALTUS
Tributary Sampling Site
Lake Sampling Site
0
5
10
15
20 Km.
0
10 Mi.
Scale

REPORT ON ALTUS RESERVOIR, OKLAHOMA

STORET NO. 4001

I. CONCLUSIONS

A. Trophic Condition:*

On the basis of field observations and Survey data, Altus Reservoir is considered eutrophic, i.e., nutrient rich and highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake.

Chlorophyll a values in Altus Reservoir ranged from 7.1 µg/l in the summer to 26.8 µg/l in the fall, with a mean of 14.8 µg/l. Potentials for primary production as measured by algal assay control yield were moderate in spring and high during October sampling. Of the 16 Oklahoma lakes (including Lake Texoma) sampled in 1974, 9 had higher median total phosphorus values, 15 had higher median inorganic nitrogen values, and 11 had higher median orthophosphorus levels than Altus Reservoir.

Survey limnologists did not report any problem algal blooms or aquatic macrophytes during their visits to the lake.

*See Appendix E.

B. Rate-Limiting Nutrient:

Mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were 11/1 or less on all sampling occasions, indicating primary limitation by nitrogen in the reservoir. Algal assay results suggest Altus Reservoir was limited by available phosphorus levels in March and colimited by both phosphorus and nitrogen during October sampling.

C. Nutrient Controllability:

1. Point sources -

During the sampling year there was one known point source, Quartz Lodge, impacting Altus Reservoir. However, no chemistry or flow data are available on the plant at this time and nutrient loadings for the plant are not included in the lake nutrient budget (pp. 15 and 16). In addition, it is suspected that a portion of the sewage treatment plant effluent from Granite, released to ground, ultimately will impact Altus Reservoir, but estimates of loading directly attributable to this source are not presently available.

The present estimated annual phosphorus loading of 0.45 g $P/m^2/yr$ to the reservoir is greater than that proposed by Vollenweider (1975) as "eutrophic" for a lake with such volume and retention time. Additional investigation is needed to determine loading levels contributed by the Quartz Lodge plant.

F. Nonpoint sources -

Nonpoint sources (including precipitation) contributed all of the calculated loading to Altus Reservoir during the sampling year. The North Fork Red River contributed 88.9%, Lake Creek contributed 2.7%, and ungaged drainage areas contributed an estimated 4.2%.

The phosphorus export rates of the North Fork Red River and Lake Creek were 2 and 3 kg/km^2/yr, respectively, (see Section IV-D). The rates are somewhat lower than those of the unimpacted tributaries draining into nearby Elsworth Lake* (range of 3-6 kg/km^2/yr).

*See Working Paper No. 583, "Report on Elsworth Lake".

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were provided by the Oklahoma Department of Pollution Control. Tributary flow data were provided by the Oklahoma District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Tributary drainage areas plus the lake surface area do not equal the outlet drainage area probably because of differences in the pool elevation used by the different sources in their calculations. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 25.41 km^2.
2. Mean depth: 6.4 meters.
3. Maximum depth: 23.5 meters.
4. Volume: 162.624 x 10^6 m^3.
5. Mean hydraulic retention time: 759 days (2.1 yr).

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area(km²)	Mean flow (m³/sec)
A-2 North Fork Red River	5185.2	3.92
B-1 Lake Creek	107.0	0.11
Minor tributaries and immediate drainage -	147.6	0.16
Totals	5439.8	4.09

2. Outlet -

A-1 North Fork Red River	5480.4	2.46

C. Precipitation:

1. Year of sampling: 77.7 cm.
2. Mean annual: 63.5 cm.

III. LAKE WATER QUALITY SUMMARY

Altus Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake (Station 03 was only sampled twice) and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 9.8 meters at Station 01, 4.9 meters at Station 02, and 7.9 meters at Station 03. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

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B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/29/74	1. Oscillatoria	7,319
	2. Chroomonas	832
	3. Carteria	155
	4. Dactylococcopsis	77
	5. Stephanodiscus	77
	Other genera	117
	Total	7,977
06/10/74	1. Oscillatoria	1,330
	2. Chroomonas	272
	3. Carteria	242
	4. Microcystis	242
	5. Merismopedia	212
	Other genera	664
	Total	2,962
10/24/74	1. Navicula	4,928
	2. Oscillatoria	1,417
	3. Centric diatoms	667
	4. Cryptomonas	206
	5. Lyngbya	206
	Other genera	309
	Total	7,761

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/29/74	01	10.9
	02	11.4
	03	****
06/10/74	01	7.3
	02	9.0
	03	8.2
10/24/74	01	25.4
	02	10.0
	03	26.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spiked(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum Yield (mg/l-dry wt.)
a. 03/29/74			
Control	0.010	0.070	0.5
0.05 P	0.060	0.070	2.6
0.05 P + 1.0 N	0.060	1.070	22.2
1.00 N	0.010	1.070	0.5
b. 10/24/74			
Control	0.021	0.170	4.0
0.05 P	0.071	0.170	6.3
0.05 P + 1.0 N	0.071	1.170	25.5
1.00 N	0.021	1.170	5.7

B. Discussion :

The control yields of the assay alga, Selenastrum capricornutum, indicate that potential for primary production was moderate in Altus Reservoir during spring sampling and high during autumn. In March, the addition of orthophosphorus alone produced a significant increase in yield over that of the control, indicating the sample was phosphorus limited at that time. The addition of nitrogen alone did not result in a significant increase in yield over that of the control. In October, additions of either phosphorus or nitrogen produced similar growth responses, suggesting colimitation by the two nutrients. In both assays, the simultaneous addition of both phosphorus and nitrogen produced the maximum yield increase over their respective control yields.

The mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were 11/1 or less on all sampling occasions, suggesting that nitrogen was the primary controlling nutrient limiting productivity in Altus Reservoir (a mean N/P of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Oklahoma National Guard collected a number of monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), including the high runoff month of April when two samples were collected. Sampling was begun in December 1974, and was completed in September 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Oklahoma District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries except North Fork Red River at Station A-1 were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any. Loadings for the North Fork Red River, Station A-1, were calculated from mean annual concentrations and mean annual flows. It should be noted, however, that loadings for A-1 are calculated from limited data (Station A-1 was sampled only four times during the 1974 sampling year) and may not reflect actual nutrient loadings from that tributary.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in kg/km^2/year, in Lake Creek at Station B-1, and multiplying the means by the ZZ area in km^2.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow ($m^3/d \times 10^3$)	Receiving water
Quartz Lodge*	?	?	?	Altus Reservoir
Granite**	900	Stabilization pond, released to ground	0.341***	

2. Known industrial - None

*Peavy, Howard S., personnal communication.
**U.S.EPA, 1971.
***Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 North Fork Red River	9,520	88.9
B-1 Lake Creek	290	2.7
b. Minor tributaries and immediate drainage (nonpoint load) -	445	4.2
c. Known municipal STP's -		
Quartz Lodge	?	
d. Septic tanks* -	5	<0.1
e. Known industrial - None		
f. Direct precipitation** -	445	4.2
Totals	10,705	100.0
2. Output - A-1 North Fork Red River	3,910	
3. Net annual P accumulation	6,795	

*Estimate based on 8 lakeside residences and 1 park.
**Estimated (See NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 North Fork Red River	855,890	94.6
B-1 Lake Creek	8,080	0.9
b. Minor tributaries and immediate drainage (nonpoint load) -	11,220	1.2
c. Known municipal STP's -		
Quarts Lodge	/	
d. Septic tanks* -	120	<0.1
e. Known industrial - None		
f. Direct precipitation** -	27,435	3.1
Totals	902,745	100.0
2. Output - A-1 North Fork Red River	96,825	
3. Net annual N accumulation	805,920	

*Estimate based on 8 lakeside residences and 1 park.
**Estimated (See NES Working Paper No. 176).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
North Fork Red River	2	165
Lake Creek	3	76

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
C-1 Unnamed Stream	0.208	2.704

Phosphorus levels in Unnamed Stream, tributary C-1, are substantially higher than those found in the other gaged tributaries to Altus Reservoir. The reasons for these inflated phosphorus values are not known.

f. Yearly Loading:

In the following table, the existing phosphorus annual loading is compared to those proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not be applicable to water bodies with very short retention times or in which light penetration is severely restricted from high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Altus Reservoir	0.42
Vollenweider's "eutrophic" loading	0.34
Vollenweider's "oligotrophic" loading	0.17

V. LITERATURE REVIEWED

Peavy, Howard S. 1974. Personal communication (Sewage Treatment Plant to Altus Reservoir). Oklahoma Department of Pollution Control, Oklahoma City, Oklahoma.

U.S. Environmental Protection Agency. 1971. "Inventory of Wastewater Treatment Facilities". EPA Publication No. OWP-1, Volume 6. Office of Media Programs, Office of Water Programs, Washington, D.C.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

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	[illegible]	[illegible]	[illegible]	[illegible]					

APPENDIX C

PHYSICAL AND CHEMICAL DATA

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[illegible]

[illegible]

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APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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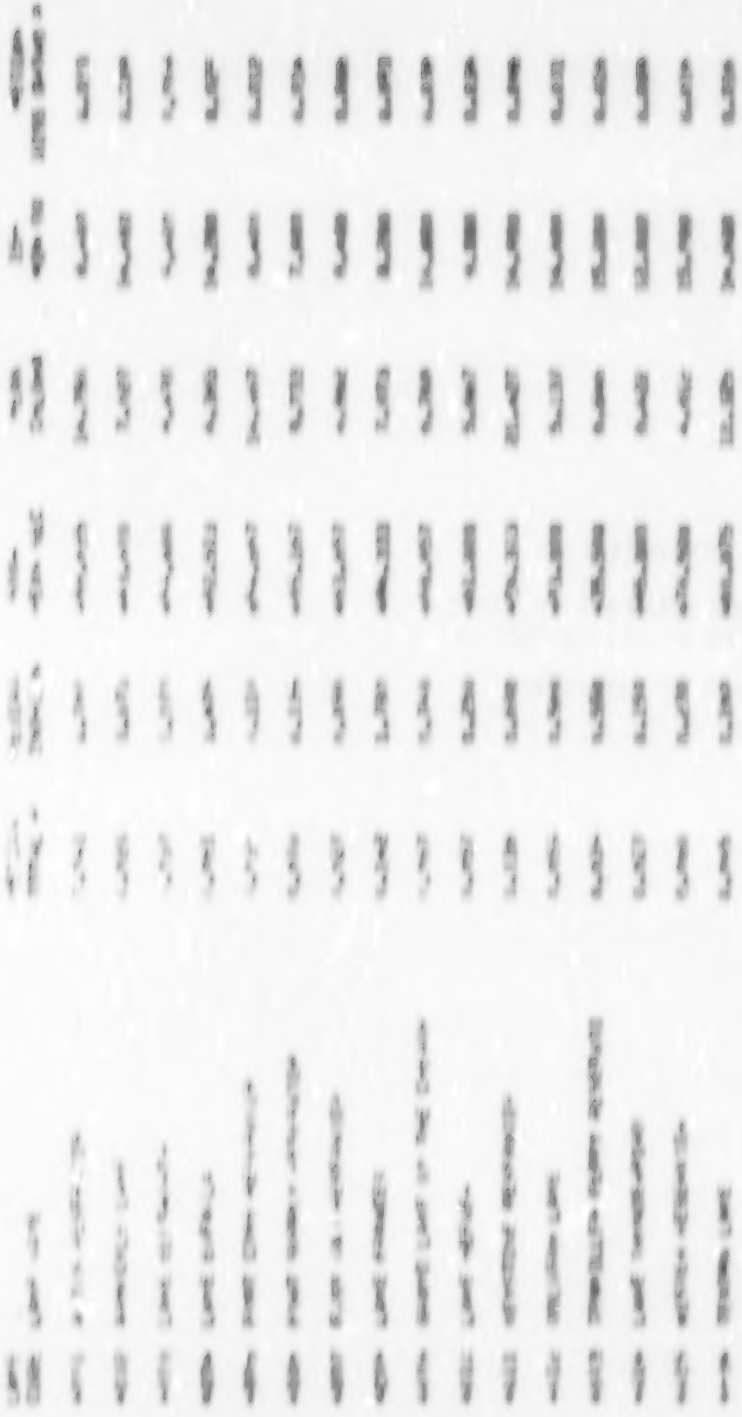
APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF OKLAHOMA



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